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Smart agriculture for climate change in recent world

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Abstract
Between now and 2050, the world's population will increase by one-third. Most of these additional 2 billion people will live in developing countries. At the same time, more people will be living in cities. If current income and consumption growth trends continue, FAO estimates that agricultural production will have to increase by 60 percent by 2050 to satisfy the expected demands for food and feed. Agriculture must, therefore, transform itself if it is to feed a growing global population and provide the basis for economic growth and poverty reduction. Climate change will make this task more difficult under a business-as-usual scenario, due to adverse impacts on agriculture, requiring spiraling adaptation and related costs. At the same time, climate change threatens production's stability and productivity. In many areas of the world where agricultural productivity is already low and the means of coping with adverse events are limited, climate change is expected to reduce productivity to even lower levels and make production more erratic (Stern Review 2006; Cline 2007; Fisher *et al*. 2002; IPCC 2007). Long-term changes in the patterns of temperature and precipitation, that are part of climate change, are expected to shift production seasons, pest and disease patterns, and modify the set of feasible crops affecting production, prices, incomes and ultimately, livelihoods and lives.

Keywords: climate smart agriculture, climate change, economic growth, poverty reduction, agricultural productivity

Introduction

Over the past six decades, world agriculture has become considerably more efficient. Improvements in production systems and crop and livestock breeding programmes have resulted in a doubling of food production while increasing the amount of agricultural land by just 10 percent. However, climate change is expected to exacerbate the existing challenges faced by agriculture. The purpose of this paper is to highlight that food security and climate change are closely linked in the agriculture sector and that key opportunities exist to transform the sector towards climate-smart systems that address both. The production, processing, and marketing of agricultural goods are central to food security and economic growth. Products derived from ethonobotanical (Tamizhazhagan and Pugazhendy, 2017) [11] and animals' earthworms (Tamizhazhagan *et al*., 2016) [15] include foods (such as cereals, vegetables, fruits, fish and meat), fibers (such as cotton, wool, hemp and silk), fuels (such as dung, charcoal and biofuels from crops and residues) and other raw materials (including medicines, building materials, resins, etc.).

Production has been achieved through a number of production systems which range from smallholder mixed cropping and livestock systems to intensive farming practices such as large monocultures and intensive livestock rearing. The sustainable intensification of production, especially in developing countries, can ensure food security and contribute to mitigating climate change by reducing deforestation and the encroachment of agriculture into natural ecosystems (Burney *et alII*, 2010 and Bellassen, 2010).

The overall efficiency, resilience, adaptive capacity and mitigation potential of the production systems can be enhanced through improving its various components, some of the key ones are highlighted below. Examples of production systems are provided at the end of the section to illustrate the feasibility and constraints of developing climate-smart agriculture.

Implications for climate-smart agriculture initiatives

Mitigation-adaptation synergies are possible. CA has been shown to increase water productivity in dry areas and can help buffer against the decreasing and more erratic rainfall likely under future climate change. Contributions to climate change mitigation through soil carbon sequestration are also possible and depend on increasing inputs of organic matter to the soil. Anticipate delayed benefits. In most cases, yield benefits with CA can take several years to emerge. Farmers are more likely to adopt CA—and continue the practices when they can see other benefits such as reduced fuel or labor use. Pairing CA promotion with fertilizer can help provide an immediate yield benefit and increase crop residues as long as it does not become a "payment" for the continued practice of CA. Consider capacities, resources, and regional contexts. Targeting CA promotion effectively requires examining factors at multiple scales: farm, village, and region. Capacities and resources of farmers, village land tenure patterns and regional infrastructures such as roads and markets can all determine the success of CA.

Be flexible

CA practices are a means to an end, not the end in themselves. The particular technologies involved in CA differ markedly between countries and even regions within a country.

Sometimes a particular practice (e.g. crop rotation) may be dropped altogether. Policies to scale up CA should not be overly prescriptive, as a local adaptation by farmers is necessary and desired. Look beyond the crops. Some opportunities such as associating support for CA with efforts to increase livestock productivity are not immediately obvious. Adaptation to climate change often requires shifts in entire farming systems, and CA practices may be just one piece of the puzzle.

Defining the concept

Climate-smart agriculture (CSA), as defined and presented by FAO at the Hague Conference on Agriculture, Food Security and Climate Change in 2010, contributes to the achievement of sustainable development goals. It integrates the three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges. It is composed of three main pillars:

1. Sustainably increasing agricultural productivity and incomes;
2. Adapting and building resilience to climate change;
3. Reducing and/or removing greenhouse gases emissions, where possible. CSA is an approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change. The magnitude, immediacy and broad scope of the effects of climate change on agricultural systems create a compelling need to ensure comprehensive integration of these effects into national agricultural planning, investments, and programs. The CSA approach is designed to identify and operationalize sustainable agricultural development within the explicit parameters of climate change.FAO and its partners are aware that achieving the transformations required for CSA and meeting these multiple objectives requires an integrated approach that is responsive to specific local conditions. Coordination across agricultural sectors (e.g. crops, livestock, forestry, and fisheries), as well as other sectors, such as with energy and water sector development, is essential to capitalize on potential synergies, reduce trade-offs and optimize the use of natural resources and ecosystem services. To address this complex task and support member countries, FAO's different departments have worked together to articulate the concept of CSA. In carrying out this work, the Organization provides guidance about the practices, technologies, policies, and financing that are required to achieve a productive, resilient and sustainable agriculture sector.

This approach also aims to strengthen livelihoods and food security, especially of smallholders, by improving the management and use of natural resources and adopting appropriate methods and technologies for the production, processing, and marketing of agricultural goods. To maximize the benefits and minimize the trade-offs, CSA takes into consideration the social, economic, and environmental context where it will be applied. Repercussions on energy and local resources are also assessed. A key component is the integrated landscape approach that follows the principles of ecosystem management and sustainable land and water use. CSA seeks to support countries in putting in place the necessary policy, technical and financial means to main stream climate change considerations into agricultural sectors and provide a basis for operationalizing sustainable agricultural development under changing conditions. Innovative financing mechanisms that link and blend climate and agricultural finance from public and private sectors are a key means for implementation, as are the integration and coordination of relevant policy instruments and institutional arrangements. The scaling up of climate-smart practices will require appropriate institutional and governance mechanisms to disseminate information, ensure broad participation and harmonize policies. It may not be possible to achieve all the CSA objectives at once. Context-specific priorities need to be determined, and benefits and tradeoffs evaluated. CSA is not a single specific agricultural technology or practice that can be universally applied. It is an approach that requires site-specific assessments to identify suitable agricultural production technologies and practices.

This approach

1. addresses the complex interrelated challenges of food security, development and climate change, and identifies integrated options that create synergies and benefits and reduce trade-offs;
2. recognizes that these options will be shaped by specific country contexts and capacities and by the particular social, economic, and environmental situation where it will be applied;
3. assesses the interactions between sectors and the needs of different involved stakeholders;
4. identifies barriers to adoption, especially among farmers, and provides appropriate solutions in terms of policies, strategies, actions and incentives;
5. seeks to create enabling environments through a greater alignment of policies, financial investments and institutional arrangements;
6. strives to achieve multiple objectives with the understanding that priorities need to be set and collective decisions made on different benefits and trade-offs;
7. should prioritize the strengthening of livelihoods, especially those of smallholders, by improving access to services, knowledge, resources (including genetic resources), financial products and markets;
8. addresses adaptation and builds resilience to shocks, especially those related to climate change, as the magnitude of the impacts of climate change has major implications for agricultural and rural development;
9. considers climate change mitigation as a potential secondary co-benefit, especially in low-income, agricultural-based populations;
10. Seeks to identify opportunities to access climate-related financing and integrate it with traditional sources of agricultural investment finance.

Enable farmers to overcome barriers to change

Land use and management play a crucial role in improving agricultural practices to address food security and climate change. Improving land management, soil fertility, or practices like implementing agro-forestry have long-term benefits but often imply upfront costs either in inputs or labour. Securing land tenure is paramount to enable farmers to benefit from the value added on the land and to encourage them in adopting a long-term perspective. The Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security7 recently adopted by the Committee on World Food Security promote secure tenure rights and equitable access to land, fisheries and forests as a means of eradicating hunger and poverty, supporting sustainable development and enhancing the environment.

They can play an important role. Whatever the change in farming systems envisaged or implemented, it involves costs. Even if a new practice will provide the same or an increased income in the long run, there are barriers to adoption: upfront costs, income foregone during the transition period or additional risks during the transition period which all have to be covered. Take for instance mitigation measures mitigation measures in the agricultural sector are considered among the cheapest, with a quarter of the technical mitigation potential being estimated as costing less than 20$/tCO2 (IPCC, 2007b). But these estimations compare the income with a new practice to the income without the practice. They do not take into account transition costs, or the costs of the enabling environment, such as extension services for instance.

These costs have to be assessed and taken into account (FAO, 2009a).The recent report of the High Level Panel of Experts on food security and nutrition on Social Protection for Food Security (HLPE, 2012b) shows how social protection can be a powerful means to enable farmers, and especially the more vulnerable, to invest and modify their practices to improve their food security. Many measures, such as providing inputs or public works to improve infrastructures and landscapes have both direct short term and longer term impacts. In cash subsidies provided as social protection are often used to invest for improving livelihoods (HLPE, 2012b).

Moreover an integrated and up-scalable social protection system is essential to enable investment particularly of the more vulnerable.It is also essential to facilitate access to the needed knowledge, including for local specific practices, through the development and improvement of extension services and initiatives such as farmer field schools and formal and informal knowledge sharing networks (HLPE, 2012).

Agro forestry

Agro forestry is the use of trees and shrubs in agricultural crop and/or animal production and land management systems. It is estimated that trees occur on 46 percent of all agricultural lands and support 30 percent of all rural populations (Zomer et. al 2009). Trees are used in many traditional and modern farming and rangeland systems. Trees on farms are particularly prevalent in Southeast Asia and Central and South America. Agroforestry systems and practices come in many forms, including improved fallows, taungya (growing annual agricultural crops during the establishment of a forest plantation), home gardens, growing multipurpose trees and shrubs, boundary planting, farm woodlots, orchards, plantation/crop combinations, shelterbelts, windbreaks, conservation hedges, fodder banks, live fences, trees on pasture and tree apiculture (Nair, 1993 and Sinclair, 1999).

The use of trees and shrubs in agricultural systems help to tackle the triple challenge of securing food security, mitigation and reducing the vulnerability and increasing the adatability of agricultural systems to climate change. Trees in the farming system can help increase farm incomes and can help diversify production and thus spread risk against agricultural production or market failures. This will be increasingly important as impacts of climate change become more pronounced. Trees and shrubs can diminish the effects of extreme weather events, such as heavy rains, droughts and wind storms. They prevent erosion, stabilize soils, raise infiltration rates and halt land degradation. They can enrich biodiversity in the landscape and increase ecosystem stability. Trees can improve soil fertility and soil moisture through increasing soil organic matter.

Nitrogen-fixing leguminous trees and shrubs can be especially important to soil fertility where there is limited access to mineral fertilizers. Improved soil fertility tends to increase agricultural productivity and may allow more flexibility in the types of crops that can be grown. For example agroforestry systems in Africa have increased maize yields by 1.3 and 1.6 tons per hectare per year (Sileshi *et alII*. 2008). Fodder trees have been traditionally used by farmers and pastoralists on extensive systems but fodder shrubs such as calliandra and leucaena are now being used in more intensive systems, increasing production and reducing the need for external feeds (Franzel, Wambugu and Tuwei, 2003). Agroforestry systems for fodder are also profitable in developed countries. For example, in the northern agricultural region of western Australia, using tagasaste (Chamaecytisus proliferus) has increased returns to farmers whose cattle formerly grazed on annual grasses and legumes (Abadi *et alII*., 2003). Agroforestry systems are important sources of timber and fuelwood throughout the world in both developing and developed countries. For example, intercropping of trees and crops is practiced on 3 million hectares in China (Sen, 1991) and in the United Kingdom; a range of timber/cereal and timber/pasture systems has been profitable to farmers (McAdam, Thomas and Willis 1999).

Trees produced on farm are major sources of timber in Asia (e.g. China, India, and Pakistan), East Africa (e.g. Tanzania) and Southern Africa (e.g Zambia), Increasing wood production on farms can take pressure off forests, which would otherwise result in their degradation. Agroforestry systems tend to sequester much greater quantities of carbon than agricultural systems without trees. Planting trees in agricultural lands is relatively efficient and cost effective compared to other mitigation strategies, and provides a range of co-benefits important for improved farm family livelihoods and climate change adaptation. There are several examples of private companies supporting agroforestry in exchange for carbon benefits. Agroforestry is therefore important both for climate change mitigation as well as for adaptation through reducing vulnerability, diversifying income sources, improving livelihoods and building the capacity of smallholders to adapt to climate change. However, agroforestry in many regions is still constrained by local customs, institutions and national policies. There is an urgent need for capacity building, extension and research programmes to screen and to match species with the right ecological zones and agricultural practices. There is a need to support and develop private public sector partnerships to develop and distribute agroforestry germplasm, like there is for the crops sector.

Technology access for effective adaptation

In the context of agricultural adaptation, smallholder farmers need to be able to choose, use, and capitalize on technologies that improve their livelihoods and well-being, while enabling them to respond effectively to continuous and unpredictable climate change. The following section analyses the challenges and opportunities of CSA practices in relation to technology access, and argues that agroecological approaches are key to strengthening smallholder resilience. Systems of food production and trade exist and function, albeit imperfectly; to achieve food security and economic development in countries where the majority of the population is employed in the agricultural sector, these systems must be made more accessible for smallholder farmers.

Conclusion

Monitoring and evaluation are initiated during the project preparation stage of the project cycle and are closely linked with the overall CSA planning. Monitoring tracks progress, checks intermediate results, and informs adjustments during the project implementation. Evaluation deals primarily with the assessment of the results and impacts of CSA interventions. The learning process identifies issues and draws lessons for future interventions and policies and should be integrated into the monitoring and evaluation process. The monitoring and evaluation framework presented in this module has six major elements: situational analysis and forecasting; intervention planning and targeting, and defining detailed indicators; implementation and monitoring; evaluation; monitoring and evaluation as closely related activities; and the importance of learning. The interventions should be designed within a results-based framework with particular emphasis on the development of appropriate indicators. There are eight unique challenges for assessment, monitoring and evaluation for CSA: the difficulty of setting the goals and an agreed definition of CSA; the multi-sectoral nature of CSA and the involvement of various stakeholders; the issues of scale, leakage, permanency, externality and ancillary impact; the difficulty of obtaining quality data and information; the uncertainties with data, information, and methods; difficulty of attribution; inadequate capacity and resources; and the practicality of methods and tools. Most of the guiding principles for responding to these challenges are common to any assessment, monitoring and evaluation activity for CSA.CSA practitioners are expected to use the guidance outlined in this module as a starting point for designing a more specific approach that satisfies the needs and context of a CSA plan and take into account the guiding principles.

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